NATHAN COBB

Annu. Rev. Phytopathol. 1991. 29:15–26

NATHAN AUGUSTUS COBB: The Father of Nematology in the United States*

R. N. Huettel and A. M. Golden

Nematology Laboratory, USDA ARS, Beltsville Agricultural Research Center, Beltsville, Maryland 20705

KEY WORDS: nematodes, nematode taxonomy

INTRODUCTION

Nathan Augustus Cobb, referred to as the "Father of Nematology in the United States" (56), was a Renaissance man and a man of humble beginnings. His early life experiences instilled in him the creativity, fortitude, and self-reliance that were needed to raise himself alone from age 14, to complete college with little formal pre-college education, receive his Ph.D. in Germany, and go on to found a new discipline of science called "Nematology". His scientific and technical accomplishments were impressive, as indicated by the over 250 first-authored manuscripts he produced during his career. He identified over 1000 species of nematodes, including animal parasitic, plant parasitic, free-living, fresh water, and marine forms. He made many innovative technical contributions to Nematology, including: (*a*) fixation and preservation methods; (*b*) the Cobb metal mounting slide; (*c*) adaptation of photographic equipment, light filters, and improvements in the camera lucida for microscopic use with nematodes; and (*d*) development of the first flotation device for removing nematodes from soil. A self-taught and gifted artist, his illustrations were of the highest quality. He made great contributions in many other areas of science, such as botany and plant pathology, and to the cotton industry as well.

EARLY LIFE

Nathan Augustus Cobb was born on June 30, 1859, in Spencer, Massachusetts. He was an only child. His father, a jack-of-all-trades, moved the family from place to place as various jobs became available. This disruptive lifestyle, instead of being detrimental, gave Cobb the opportunity to learn many skills that would be carried over into his future life. His early responsibilities ranged from working the night shift at a shingles mill when he was eight years old to running a 150-acre farm alone for weeks in the absence of his father. His formal education was spotty, with only an occasional winter term available that did not interfere with his work responsibilities.

When Cobb was fourteen, his father died and his mother could no longer support him. He took a job as groundskeeper and stableboy for Mr. Charles Prouty in Spencer, Massachusetts. He was fascinated by an advertisement for a microscope in a magazine sold by N. Waldstein, New York, and managed to save the $25.00 needed for its purchase, one third of his total yearly income. Entranced by what he could see with the microscope, he shared his observations with Mr. Prouty's children. Mr. Prouty, impressed with this young man's self-taught knowledge, encouraged Cobb to take the local teacher's examination, aware that he had little formal schooling. Cobb easily passed the examination and within a year was headmaster, in charge of a small school with 65 students of ages 11–18 years. During this time a friendship developed with Prouty's son, Fred, and Joseph H. Greenwood, who introduced Cobb to drawing and painting and who eventually gained fame as a New England landscape artist. This exposure to sketching and drawing would give more than pleasure to Cobb: it was to serve at times as a means of livelihood and was invaluable in his scientific illustrations.

When Cobb started his early schoolteaching career, he moved in with a family named Proctor, whose daughter, Alice, would eventually become his wife. She, too, was a teacher and very interested in botany. They spent much time together studying plants and sketching their findings. They married four years after they met and over the years had seven children.

HIGHER EDUCATION

In 1878, at the age of 19, Cobb entered the Worcester Polytechnic Institute in Massachusetts. He graduated three years later at the top of his class, majoring in chemistry since no biology was taught. His undergraduate thesis was entitled "Mathematical Crystallography" and combined analytical geometry and crystallography. The mathematical knowledge he acquired in optical applications from his undergraduate training later would aid him in developing novel microscope skills and microscope accessories that so enhanced his career.

After graduation in 1881, he taught at Williston Seminary in Easthampton, Massachusetts. His teaching duties soon included zoology, physiology, botany, and geology. He developed several comprehensive drawing courses in architectural design, mechanical drawing, and topography. In spite of his prowess in the physical sciences, his interests turned to the natural sciences, particularly to systematic botany. He published his first paper entitled "A list of plants found growing wild within thirty miles of Amherst" (3).

After six years at Williston Seminary, Cobb looked towards postgraduate education. Failing to win a scholarship at Johns Hopkins University because of his age (28 years), he pursued graduate studies in Germany. In 1887, he set off with his wife and three young children to the University of Jena. Here he was introduced to nematodes. It was during this time that Cobb's talents in mathematics, optics, and art came together with his new knowledge of biology. These combined abilities allowed him to move forward in studies of microscopic organisms. He wrote a thesis on nematodes associated with whales, entitled "Beiträge zur Anatomie und Ontogenie der Nematoden" (4). Here, also, the University published his first new nematode species in "Neue Parasitische Nematoden" (5). There is no way to know how fluent he was in the German language, but he did complete the Ph.D. requirements in just ten months!

EARLY PROFESSIONAL CAREER

Interest in nematodes and marine fauna led him to apply for a position through the British Association for the Advancement of Science at the Zoological Research Station in Naples, Italy. Surprisingly, however, it was not his knowledge of marine fauna but his artistic talents that led to his recommendation for the position. Sir John Murray, a famous oceanographer, was so impressed with a series of Cobb's water colors that he helped him secure the Naples appointment. At Naples, Cobb named his first marine nematode genus, *Tricoma,* but did not publish on it until 1894 (17).

After obtaining tenure in Naples, Cobb seized the opportunity to go to Australia even though no science position was available. Arriving in Sydney in 1889, he was unable to find suitable employment, so turned to his artistic skills and secured a job advertising oils and soaps. Putting his chemistry skills to use, he analyzed the oil and soap's contents to assure the "purity" of the company's product and included it in the advertisement. By the following year however, he had secured a part-time job as a Consulting Pathologist in the newly formed Department of Agriculture in New South Wales. Without formal training in agriculture, he relied heavily on his childhood farm experiences and quickly developed a knowledge not only of plant and animal parasitic nematodes, but also of fungal and bacterial diseases of plants. After six months, he had a permanent position as Vegetable Pathologist, the first full-time Plant Pathologist position in Australia.

Duties were extensive in this new position and his responsibilities included studies of nematodes, flukes, and tapeworms of ranch and farm animals. He conducted studies on various grains, with a major concentration on wheat and its diseases. Breeding experiments and research for handling and storage of the grains were undertaken. Acting as a de novo extension agent, he responded to letters and questions from ranchers and farmers and conducted research in their behalf. He managed the Governmental Experimental Farm at Wagga Wagga, which was 300 miles away from his office in Sydney.

Most field experiments in Wagga Wagga were on wheat. His studies on many aspects of this grain resulted in over 25 publications on the subject, including "Improving wheats by selection", 1894 (16); "Notes on the form and size of the grain in different varieties of wheat", 1895 (18); and "Notes on the threshing of wheat", 1896 (20). These studies of wheat culminated in 1905 when he produced the "Universal nomenclature of wheat" (26).

His studies of fungal pathogens, especially the rusts on wheat, revived botantical skills learned in Germany. He published not only many papers on fungi but also on all aspects of plant pathology. Some of his noted works were: "Contributions to an economic knowledge of the Australian rusts (Uredineae)", 1892 (14), "The hot-air treatments of bunt or stinking smut", 1896 (21), and "The cause of an important apple disease", 1897 (22). He also contributed new research to the bacterial disease of sugar cane called "gumming disease", sometimes referred to as Cobb's disease (19).

About the time of his appointment to the position of plant pathologist, Cobb became interested in parasitic nematodes and published his first paper on plant parasitic nematodes, "*Tylenchus* and root-gall", 1890 (10). He continued to publish on nematodes of every type. Some major contribution from 1890–1891 were on: plant parasitic nematodes, "Strawberry bunch, A new disease caused by nematodes" (13); human parasitic nematodes; "*Oxyuris* larvae hatched in the human stomach under normal conditions" (8); animal parasitic nematodes, "Parasites in the stomach of a cow" (12); marine nematodes, "*Anticoma,* a genus of free-living marine nematodes" (7); and free-living soil nematodes, "*Onxy* and *Dipeltis,* new nematode genera, with a note on *Dorylaimus*" (11).

During 1890–1891, he conducted a major study on nematodes that he isolated from diseased bananas and soil sent to him from Fiji. About 30 species of nematodes were identified, the most significant of which were *Tylenchus granulosus* and *T. similis* (15). Some future confusion arose over the identity of these species but they were finally synonymized, with *T. granulosus* being the nomen oblitum, *Tylenchus similis* being valid and finally becoming *Radopholus similis,* the type species (61). This confusion came about because the male and female of this species are sexually dimorphic, so each sex was identified as a separate species. However, this species is still known as the most important plant parasitic nematode on bananas worldwide (60). Another important paper on this nematode and its host associations, "*Tylenchus similis,* the cause of a root disease of sugar canc and banana," (41) was published after Cobb's return to the United States.

While in Australia, Cobb began the development of instrumentation, microscope techniques, and photographic adaptations that were to aid in future studies of nematodes. One such invention was an instrument called a "Differentiator" (6). The purpose of this device was to use a gradient approach to fixation and preservation of delicate organisms. This allowed for gentle dehydration in alcohol, staining in borax-carmine, and a final embedding in balsam. The oldest known slide of Cobb's, dated June, 1890, of *Mononchus longicaudatus* was embedded by this method (57). This technique was used throughout his career, only the stains used were changed.

He also developed a tool for the handling of human parasitic eggs and larvae of *Oxyuris* spp. For handling these small organisms, he developed a suction capsule that held eggs of the human parasitic nematodes and that could be swallowed. The capsule containing the nematode eggs would suck in stomach juices but not release the eggs into the stomach. Once passed in the feces, it could be recovered. Egg hatch proved that the human body could be a reservoir of these pests and that the acid stomach juices would not destroy them. Cobb states in his paper, "Two new instruments for biologists", that he tried the capsule many times with great success (9).

In 1905, Cobb left Australia for Hawaii where he helped to establish and direct the Division of Pathology and Physiology of the Hawaiian Sugar Planters Association Experiment Station in Honolulu. Here he studied and published on the diseases of sugar cane, especially fungal diseases, "Fungus maladies of sugar cane", 1906, 1909 (28, 29). In his first fungal paper, he outlined the approaches to field studies, made valuable suggestions on how to collect field data, to set up plots and to use nematode sampling techniques. He stated that:

> It would be folly to spend large sums of money on the production of new varieties, then fail, through poorly conducted trails or bad reasoning, to reap the good results. . . . (28).

The taxonomic studies of nematodes continued while in Hawaii and many new species of nematodes associated with sugar cane were described. In the 1906 paper, he identified a "protozoan" parasite of *Dorylaimus,* which was the first known identification of a parasite of nematodes (28).

His optical and mathematical skills led him to the development of instrumentation that provided new approaches in microscopic techniques. As early as 1897 (23), he proposed novel microscopic techniques and would continue to publish his many improvements on the microscope itself, new ways to filter light, and major improvements on the camera lucida system. In 1905, while in Hawaii, he proposed substituting of a 45° prism for the mirror that was commonly used at that time for camera lucida. This approach greatly reduced damage to eyesight. Also, the prism had the advantages of increasing magnification of the object as well as helping to reduce the effect of a second image or reflection (25). Cobb also designed microscope rooms (27), anti-vibration tables (42), and his most famous revolving microscope table pictured in Figure 1. This table allowed him to have several specimens available for comparison at the same time.

UNITED STATES DEPARTMENT OF AGRICULTURE

In 1907, at the request of Erwin F. Smith, Cobb accepted the job of Crop Technologist for the United States Department of Agriculture in Washington, D.C. This title was soon changed to Agricultural Technologist. Though he was hired to work on nematodes, a great deal of this time (until 1915) was spent on cotton and quality of its fibers. His knowledge of so many scientific and technical subjects allowed him to work not only on the process of spinning and milling cotton, but also the storage and marketing of this commodity. He contributed several inventions to the cotton industry that were of great benefit worldwide. One of these studies was entitled "An accurate

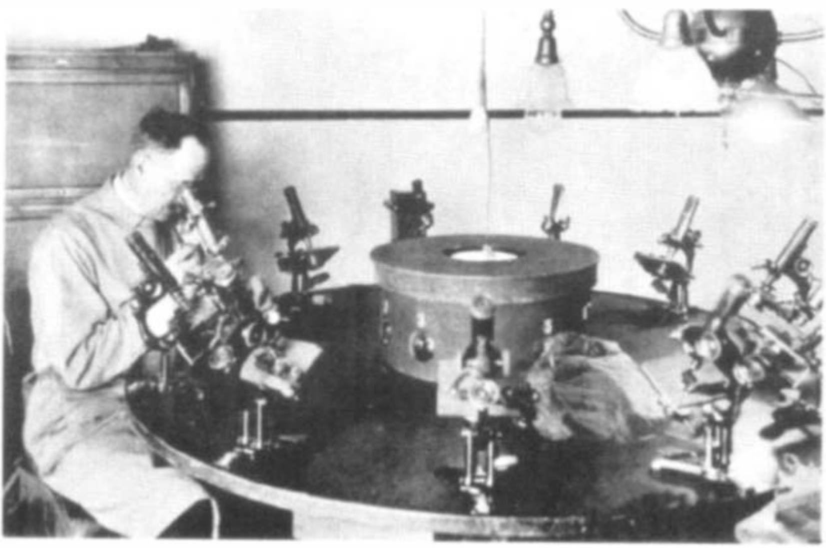

Figure 1 Cobb working at his revolving microscope table, USDA, Division of Plant Industry, Washington, DC

method of measuring cotton staple", 1912 (30). Two very important government pamphlets were authored by Cobb, "Memorandum of information concerning official cotton grades" (32) and "United States official cotton grades" (35) that helped to set standards for US cotton grades. He was presented a medal by the National Cotton Manufacturers Association for his contributions to the cotton fiber industry.

In 1910, he was called upon as the USDA nematologist to aid in the inspection of cherry trees sent to Washington, D.C. in 1909 as a gift from the Japanese government. First Lady, Helen H. Taft had proposed a beautification project along the Potomac River in the area that would become known as the Tidal Basin. As a gesture of friendship, the city of Tokyo offered to send 2000 young cherry trees to its sister city. When the trees arrived they were severely infested with several species of insects as well as root-knot nematodes. The Department of Agriculture recommended the destruction of these trees, which presented an embarrassing political situation (see Ref. 58 for a complete history).

In a letter to the Secretary of Agriculture on January 19, 1910, C. L. Marlatt, Acting Chief of the Bureau of Entomology, stated:

> *Root gall worm:* Doctor Cobb's inspection indicates that about 72% of the different lots of trees are infested with root gall worm. He reports that in all probability the vast majority of the trees are infested with gall worm, and that the soil attached to the roots contains large numbers of various species of nematodes, among which are a number of very injurious species. He (Cobb) concludes: "I have no hesitation in saying that in a country where a proper inspection of disease material was legally in force with the object of protecting agriculture, the importation of these trees would not be permitted. Root gall is a very serious disease which attacks scores of species of cultivated and wild plants. . . ." (59).

This statement by Cobb was to have a major impact on the quarantine regulations of the United States. At the time of the first shipment of cherry trees, there were no national quarantine laws. In 1912, when the first Plant Quarantine Act was passed Cobb served as one of its authors (62).

Many of his publications on nematodes during his first few years at the USDA were from studies conducted in Naples and Australia but never published. He continued his work on *Tricoma,* "Further notes on *Tricoma*", 1912 (31) and on "*Draconema,* A remarkable genus of marine free-living nematodes", 1913 (33). In 1914, he published a paper on marine nematodes that were collected on an expedition from Australia to the Antarctic. In this paper, "Free-living nematodes of the Shackleton Expedition" (38), he first proposed that Nematology be named such and recognized as a separate science:

> *Nematology*—A contraction of Nematodology. The founding of this branch of science, on a par with Entomology for example, is fully justified by the fact that the Nematodes

> constitute such a distinct and highly characteristic group of organisms, containing an enormous number of species readily susceptible of division into definite orders, some of which are of great economic importance.

The following year in another publication, "Nematodes and their relationships" (39), he again described Nematology. This particular publication is most often cited as his first definition. However, this lengthy essay covers the history, habitat, relationships in the soil, as well as morphology and physiology of all types of nematodes. He redescribes Nematology at the end of this publication as follows:

NEMATOLOGY

> The foregoing fragmentary sketch may indicate to the student, as well as to the general reader, the vast number of nematodes that exist, the enormous variety of their forms, and the intricate and important relationships they bear to mankind and the rest of creation. They offer an exceptional field of study, and probably constitute almost the last great organic group worthy of a separate branch of biological science comparable with entomology—Nematology.

Throughout the rest of his career Cobb would contribute scientific names and descriptions of over 1000 nematode species. He studied morphology as well as physiology, host relationships, and habitats. In 1913, he described 26 new species of nematodes in "New nematode genera found inhabiting fresh water and non-brackish soils" (34). In this publication he identified the first ectoparasitic plant nematodes, *Tylenchorhynchus cylindricus, Trichodorus obtusus,* and *Xiphinema americanum*. It would be years before the importance of this group of nematodes would be appreciated. Another of his major studies entitled simply, "The mononchs", 1917 (45), contained over 75 illustrations plus a glossary of abbreviations for the labeled drawings and a descriptive key to the genus. His publications ranged from the description of only one new nematode species to, in one case, "One hundred new nemas", 1920 (50). He covered a large number of plant parasitic nematodes and their associated hosts. For example, he investigated a variety of plant hosts, such as "Nemic diseases of narcissus", 1926 (53), "A new parasitic nema found infesting cotton and potatoes", 1917 (43), and "Losses in slash pine seedlings due to nemas", 1930 (54).

He conducted many studies throughout his career on the root-gall nematode. His first description of this nematode was in 1890 (10) while in Australia, not knowing it had already been described as *Heterodera radicicola* (Greef) Muller. He continued his studies on this nematode, "Root-gall", 1901 (24), "The control of root-knot", 1915 (40), and even used it as an experimental tool, "Effect of X-rays on *Heterodera radicicola*", 1920 (48).

He was the first to recognize that *H. radicicola* was different from the other *Heterodera* spp. and named the new genus, *Caconema* (51). He based this new genus on the presence of two lateral cheeks on the head and two testes in males. This definition was noted in a publication by Chitwood who renamed the genus in 1949 (2). Chitwood recognized that the little-known name first proposed by Goeldi in 1887 as *Meloidogyne* was the nomen a priori and therefore synonomous with *Caconema radicicola,* Cobb 1924.

Cobb's first studies on development and morphology of nematodes were published in his dissertation in 1888 (4) and continued throughout his career. Cobb's proficiency in light microscopy gave him a distinct advantage in conducting his morphological studies. Organs and organelles difficult to observe in nematodes were differentiated and he began to assign form to function. In 1913, descriptions of the amphids in the head regions on nematodes were offered. He defined them as "paired cephalic structures of specialized (unknown) function" (36). In 1917, he proposed that the amphids appear to be more like "ducts" based on their histology than nerve organs, as previously proposed by other workers (44). Cobb pointed out that it was difficult to separate lateral papillae from amphids and care should be taken in descriptive studies. He contributed detailed illustrations of the reproductive structures of nematodes, including many papers on spermatogenesis. In the 1925 publication "Nemic spermatogenesis", intricate studies were conducted on meiosis in the sperm of *Spirina parasitifera* (52), presented as drawings of chromosome divisions in sperm, in the female reproductive system, and in fertilization of the ova.

Cobb often took the opportunity to redescribe many genera of nematodes and add new species to a genus that helped to strengthen its taxonomic position. His classification system, started in 1919, proposed a high-level hierarchy, "The orders and classes of Nemas" (47). He divided nematodes into two subphylla; Alaimia, those without a distinct pharynx, and Laimia, those with a distinct pharynx and with a onchia (spear). He continued with class, subclass, order, and genus. In 1935, three years after his death, his daughter, Margaret, and Corrine Cooper published his most comprehensive work, "The key to the genera of free-living nematodes" (55). This publication represented the accumulation of forty years of data that he had almost completed at the time of his death. This epitome uses the taxonomic scheme he developed in 1919 and it contains over 1200 entries, close to the number of described nematodes known at that time. Even though the nomenclature has drastically changed, the extensive literature citations for all named species is invaluable.

Cobb introduced many methods into nematology that are still used today. Any student of nematology would be able to describe the "Cobb slide" he developed in 1917 (44). Its metal frame and the two-coverslip system easily allow for observation of both sides of the specimen and easy remounting of old specimens. Another still commonly used technique is the use of glycerine jelly for *en face* mounts, which he developed in 1920 (49). He first suggested using the Syracuse Dish for counting nematodes in 1918, "Estimating the nema populations of soil" (46). In this publication, he first introduced a soil-sampling tube, a device for the separation of nematodes from soil, and directions for the first cross-hair eyepiece for counting nematodes. This remarkable device was made with spider webs (46).

Death came unexpectedly on June 4, 1932, during a routine health check-up at Johns Hopkins Hospital, Baltimore, Maryland. It marked the end to an insightful mind that had spawned the new discipline, Nematology. The impetus for his life's devotion to the study of these organisms is best reflected in his often quoted description of their world, from "Nematodes and Their Relationships" (39):

> In short, if all the matter in the universe except the nematodes were swept away, our world would still be dimly recognizable, and if, as disembodied spirits, we could then investigate it, we should find its mountains, hills, vales, rivers, lakes, and oceans represented by a film of nematodes. The location of towns would be decipherable, since for every massing of human beings there would be a corresponding massing of certain nematodes. Trees would still stand in ghostly rows representing our streets and highways. The location of the various plants and animals would still be decipherable, and, had we sufficient knowledge, in many cases even their species could be determined by an examination of their erstwhile nematode parasites.

OTHER SIGNIFICANT INFORMATION

About 1918–1920 (exact date unknown), the Bureau of Plant Industry recognized Cobb's contributions to nematology and started a new laboratory called the Division of Nematology with Cobb as its director. This division continues today and is now called the Nematology Laboratory. It is one the oldest units in the Agricultural Research Service, United States Department of Agriculture. The laboratory was relocated at the Beltsville Agricultural Research Center, Beltsville, Maryland, in 1940. The Nematology Laboratory still houses Cobb's slide collection, an extensive collection of his literature, personal letters and drawings, many of his microscopes, prisms, and light filters as well as other items he developed for the study of nematodes.

It can be said that Cobb prepared the second generation of American nematologists. Gotthold Steiner, J. R. Christie, G. Thorne, B. G. Chitwood, A. L. Taylor, and Edna Buhrer all worked with Cobb. Gotthold Steiner took over the Nematology Laboratory after Cobb's death.

Cobb was a charter member of the Helminthological Society of Washington, which was started in 1910 and at the time called the "Worm Club". This society is now in its 81st year. Cobb served as president of the Helminthological Society of Washington, American Microscopic Society, American Society of Parasitology, and Washington Academy of Science.

ACKNOWLEDGMENT

We are indebted to his daughter, Frieda Cobb Blanchard, who, in 1957, published "Nathan A. Cobb, botantist and zoologist, a pioneer scientist in Australia" (1). This booklet gives great human insight into a man not only recognized by society as a master in science but obviously well loved and respected by his children.

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